The International Journal of Biotechnology
2013 Vol.2, No.5, pp.105-112
ISSN(e): 2306-6148
ISSN(p): 2306-9864

PERFORMANCE EVALUATION OF HYBRID UPFLOW ANAEROBIC SLUDGE BLANKET REACTOR IN THE TREATMENT OF DAIRY WASTE WATER

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ABSTRACT

Dairy industries have shown tremendous growth in size and number in most countries of the world. These industries discharge wastewater which is characterized by high chemical oxygen demand, biological oxygen demand, nutrients, and organic and inorganic contents. Such wastewaters, if discharged without proper treatment, severely pollute receiving water bodies. For treatment of dairy waste water, several physical, chemical and biological methods are available. However, dairy waste responds best to the biological processes the heavily aerated effluent is brought in contact with microorganisms, which oxidize its organic matter to carbon dioxide and water. In anaerobic processes, the microorganisms convert organic matter to biogas and cell biomass. To start with a digester was inoculated with 10%of volume of the reactor and the remaining space was filled with dairy waste water with an organic loading rate of 2.5g/l/day, 3.0g/l/day and 3.5g/l/day and was acclimatized for the development of microbial population and 10% of the reactor was left for gas collection.

Keywords: Dairy wastewater, HUASB, Anaerobic treatment, Biogas.

INTRODUCTION

The dairy industry wastewaters are primarily generated from the cleaning and washing operations in the milk processing plants. It is estimated that about 2% of the total milk processed is wasted into drains (Munavalli and Saler, 2009). The wastewaters generated from milk processing can be separated into two groups—the first group concerns wastewater having high flow rates and the second concerns the effluents produced in small milk-transformation units (cheese production for instance) (Castillo *et al.*, 2007). Dairy wastewaters are characterized by high biological-oxygen demand (BOD) and chemical oxygen demand (COD) concentrations, and generally contain fats, nutrients, lactose, as well as detergents and sanitizing agents. Nutrients lead to eutrophication of receiving waters, and detergents affect the aquatic life. Due to the high pollution load of dairy wastewater, the milk-processing industries discharging untreated/partially treated waste water which cause serious environmental problems. Thus, appropriate treatment

methods are required so as to meet the effluent discharge standards. Dairy wastewaters are generally treated using biological methods such as activated sludge process, aerated lagoons, tricklingfilters, sequencing batch reactor (SBR), anaerobic sludge blanket (UASB) reactor, anaerobic filters, etc. (Demirel *et al*., 2005). Moreover, because the dairy industry produces different products, such as milk, butter, yogurt, ice-cream, and various types of desserts and cheese, the characteristics of these effluents also vary widely both in quantity and quality, depending on the type of system and the methods of operation used (Rico Gutierrez *et al*., 1991; Vidal *et al*., 2000). Dairy wastewater contains milk solids, detergents sanitizers, milk wastes, and cleaning water. It is characterized by high concentrations of nutrients, and organic and inorganic contents. Significant variations in COD (80–95,000mg/l) and BOD (40–48,000 mg/l) have been reported by various investigators of dairy waste water . The total COD of dairy wastewater is mainly influenced by the milk, cream, or whey.

MATERIALS AND METHODS

The feed stock for the reactor was collected from Aavin dairy industry, pachapalayam, Coimbatore, Tamilnadu, India. Cow dung slurry is used as seed material for the reactor.

Reactor Set Up

A cylindrical vessel of 15cm dia and 31 cm height is fabricated with brittle glass is provided with a three nozzles. Out of three nozzles one nozzle is provided for gas collection another one is

provided for thermometer for temperature measuring and the last one is used as outlet and sampling port. The whole arrangement is kept on the magnetic stirrer of capacity5 litre and the rpm is kept as 250rpm.

Gas production

Gas production in the HUASB reactor was measured by water displacement method. The outlet of the gas port of the reactor was connected to the inlet of measuring collector.

Start up process

The HUASB reactor was acclimatized by feeding cow dung slurry for 2weeks. During this period the reactor was operated in batch mode. After acclimatization period, the reactor was operated in a continuous mode and dairy waste water was then gradually introduced .The operating parameters under which the performance of the reactor was monitored are given in Table 1. The performance of the HUASB was investigated for the treatment of dairy waste water. The organic loading rate was 2.5g COD/L/d to 3.5g COD/L/d.

Table-1.

Operating parameters	Range
Hydraulic retention time (HRT)	1-30
Organic Loading Rate (g cod/l /d)	2.5-3.5
Temperature	27-35

Analytical Techniques

The organic strength of waste water was determined by the COD method. The analyses were conducted induplicate and in some cases in triplicates and the influent and effluent parameters were analyzed as per APHA (1992).

The characteristics of dairy waste water is presented in Table 2. During this investigation the COD was measured weekly. The process performance was monitored and the COD removal efficiency of the reactor under different hydraulic retention time was noted. Experiments were conducted at mesophilic temperature (27- 35 C) (Rajeswari *et al.*, 1999). The analysis of anaerobic degradation of dairy waste in the H UASB reactor for different organic loading rates was studied and evaluated in this work. The pH, total solids, COD, BOD, sulphates and biogas collection were monitored periodically. The observations and calculations made were described in the Tables. These test were conducted in order to find the parameter variation in the effluent undergoing treatment and thereby the performance of the reactor was studied (Wijietunga and Wenquan, 2006).

Table-2. Characteristics of the dairy effluent

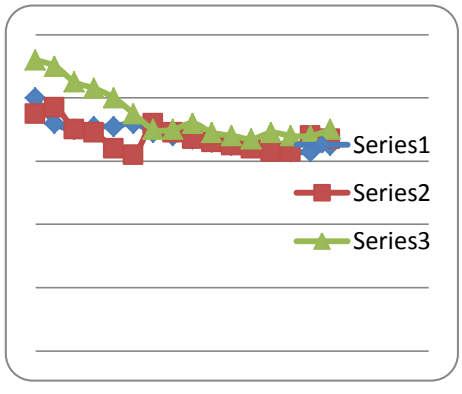
Parameters	Value
Colour	Pale white
pH	9.2
BOD	950mg/L
COD	2133mg/L
Sulphates	132 mg/L
Total solids	5200 mg/L
Total dissolved solids	881mg/L

Process investigation

Effect of HRT on pH

The pH variation was noted for various days and the results are presented in Fig. 1. As seen from the Fig the sudden fall of pH below 6.4 occurs due to acidogenesis and acitogenesis, which is toxic to the methanogenic bacteria which produces gas during methanogenesis process and make it to 7.

Fig-1. pH variation for OLR



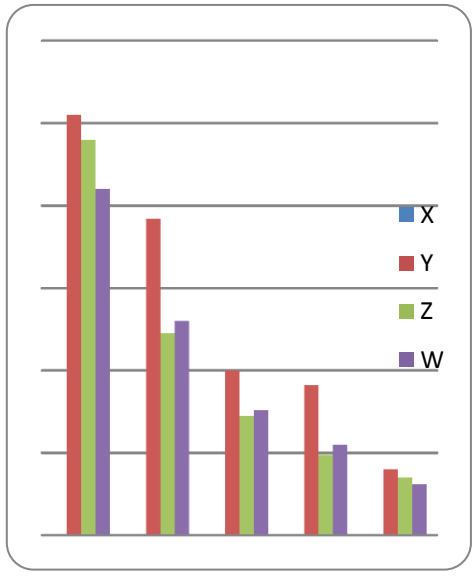
Days

Series1- OLR2.5 g/cod/day Series2- OLR 3 g/cod/day Series3- OLR 3.5 g/cod/day

Effect of HRT on COD

The effect of influent COD concentration on COD removal was studied keeping HRT as a parameter. It was observed that COD removal percentage increased with increase in hydraulic retention time(VenkatMohan.et.al).The present study also confirms this observation because the longer the HRT, the greater the efficiency of COD removal from dairy waste water. The maximum COD removal efficiency was 88%

Fig-2. COD Variation for OLR



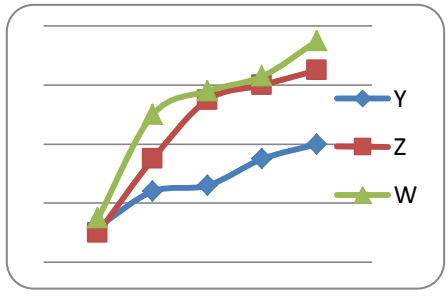
WEEKS

y- OLR2.5 g/cod/day z- OLR 3 g/cod/day w- OLR 3.5 g/cod/day

Effect of HRT on Gas collection

The reactor with magnetic stirrer designed can perform up to efficiency of about 88% COD removal when the influent organic loading rate was 3.5 g/L/day. Biogas generated from the reactor was 750mLwhen it was operated for 30days. The methane yield obtained in this study was satisfactory and comparable to results from other research using similar waste water. The UASB reactor could be suitably operated around 2.5g/L/d -3.5g/L/d .The performance of the reactor depends on the OLR, the HRT and seed sludge. The waste water released from UASB had a low concentration of total solids eliminating the need for post treatment of the effluent. The UASB thus can be used in the removal of organic load from the dairy waste water and effluent can be discharged into municipal sewer.

Fig-3. Gas Collection

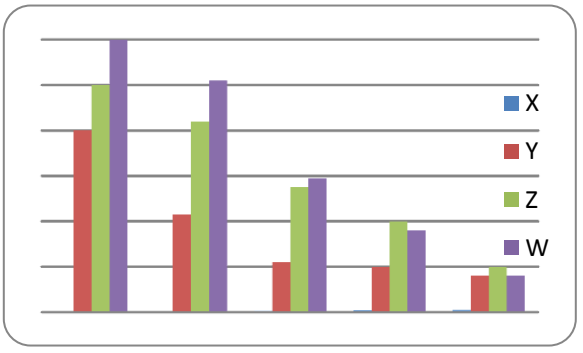


WEEKS

y- OLR2.5 g/cod/day z- OLR 3 g/cod/day w- OLR 3.5 g/cod/day

Effect of HRT on Sulphates, Total solids

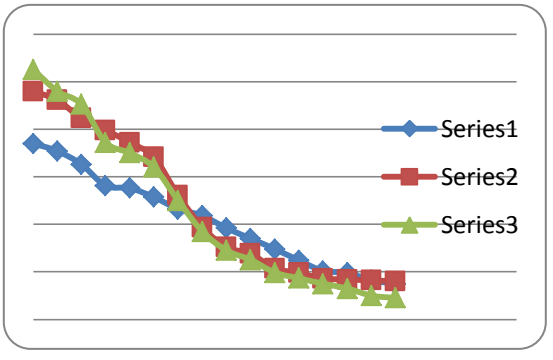
Fig-4. Sulphates



WEEKS

y- OLR2.5 g/cod/day z- OLR 3 g/cod/day w- OLR 3.5 g/cod/day

Fig-5. Total Solids



DAYS

Series1- OLR2.5 g/cod/day Series2- OLR 3 g/cod/day Series3- OLR 3.5 g/cod/day

CONCLUSION

As one of the objectives of the study was to evaluate the performance of the reactor, COD removal (%) and biogas yield were chosen as significant parameters for the above evaluation The HUASB reactor was loaded with different organic loading rates 2.5,g/L/day/, 3.0 g/l/day and 3.5 g/L/day. From the results observed the HUASB Reactor is suitable to treat the dairy waste water. It is found that operating temperature, pH of waste water, microbial population, and the magnetic stirrer for continuous stirring improves the performance of the reactor. The performance of the reactor depends on the OLR, the HRT and seed sludge. The maximum Cod removal is 88% and biogas collected is 750ml. 1) HUASB reactor has an early start-up , which is advantageous from the operation of the treatment process. It is also to be noted that the early start-up has not affected the performance of the reactor, especially, COD removal efficiency.

(2) The trend between OLR and COD removal (%) are found to be same as that of UASB reactor. For the experimental ranges of HRTs and influent COD concentrations considered.

(3) However, the maximum COD removal is 88%

(4) The trend between bio-gas yield and COD removal (%) is found to be the same as that of UASB reactor, but, the maximum gas yield is slightly better and equal to 750ml.

(5) From an overall assessment, it can be stated that the performance of the HUASB reactor is better than the UASB reactor and that the HUASB reactor contemplated in the present study is capable of handling still higher influent COD concentrations, than the experimental range of values of the present study.

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